CHAPTER

1 Introduction to Matter

the BIG idea

Everything that has mass and takes up space is matter.

Key Concepts

SECTION 1.1 **Matter has mass and volume.**
Learn what mass and volume are and how to measure them.

SECTION 1.2 **Matter is made of atoms.**
Learn about the movement of atoms and molecules.

SECTION 1.3 **Matter combines to form different substances.**
Learn how atoms form compounds and mixtures.

SECTION 1.4 **Matter exists in different physical states.**
Learn how different states of matter behave.

Internet Preview

CLASSZONE.COM

Chapter 1 online resources: Content Review, two Simulations, four Resource Centers, Math Tutorial, Test Practice

What matter can you identify in this photograph?

EXPLORE the BIG idea

What Has Changed?

Blow up a balloon. Observe it. Let the air out of the balloon slowly. Observe it again.

Observe and Think Did the amount of material that makes up the balloon change? Did the amount of air inside the balloon change? How did the amount of air inside the balloon affect the size of the balloon?

Where Does the Sugar Go?

Stir some sugar into a glass of water. Observe what happens.

Observe and Think What happened to the sugar as you stirred? Do you think you would be able to separate the sugar from the water? If so, how?

Internet Activity: Scale

Go to **ClassZone.com** to explore the smallest units of matter. Start with a faraway view of an object. Then try closer and closer views until you see that object at the atomic level.

Observe and Think Are all objects seen at faraway views made up of the same parts at an atomic level? Explain your answer.

NSTA SCILINKS scilinks.org

Solids, Liquids, and Gases **Code: MDL061**

CHAPTER 1

Getting Ready to Learn

CONCEPT REVIEW

- Matter is made of particles too small to see.
- Energy and matter change from one form to another.
- Energy cannot be created or destroyed.

VOCABULARY REVIEW

See Glossary for definitions.

particle

substance

CONTENT REVIEW
CLASSZONE.COM
Review concepts and vocabulary.

TAKING NOTES

MAIN IDEA AND DETAIL NOTES

Make a two-column chart. Write the main ideas, such as those in the blue headings, in the column on the left. Write details about each of those main ideas in the column on the right.

VOCABULARY STRATEGY

Write each new vocabulary term in the center of a **four square** diagram. Write notes in the squares around each term. Include a definition, some characteristics, and some examples of the term. If possible, write some things that are not examples of the term.

See the Note-Taking Handbook on pages R45–R51.

SCIENCE NOTEBOOK

MAIN IDEAS	DETAIL NOTES
1. All objects are made of matter.	1. All objects and living organisms are matter. 1. Light and sound are not matter.
2. Mass is a measure of the amount of matter.	2. A balance can be used to compare masses. 2. Standard unit of mass is kilogram (kg).

Definition	Characteristics
the downward pull on an object due to gravity	• standard unit is newton (N) • is measured by using a scale
WEIGHT	
Examples	**Nonexamples**
On Earth, a 1 kg object has a weight of 9.8 N.	not the same as mass, which is a measure of how much matter an object contains

KEY CONCEPT

1.1 Matter has mass and volume.

BEFORE, you learned

- Scientists study the world by asking questions and collecting data
- Scientists use tools such as microscopes, thermometers, and computers

NOW, you will learn

- What matter is
- How to measure the mass of matter
- How to measure the volume of matter

VOCABULARY

matter p. 9
mass p. 10
weight p. 11
volume p. 11

VOCABULARY
Make four square diagrams for *matter* and for *mass* in your notebook to help you understand their relationship.

EXPLORE Similar Objects

How can two similar objects differ?

PROCEDURE

1. Look at the two balls but do not pick them up. Compare their sizes and shapes. Record your observations.
2. Pick up each ball. Compare the way the balls feel in your hands. Record your observations.

MATERIALS
2 balls of different sizes

WHAT DO YOU THINK?
How would your observations be different if the larger ball were made of foam?

All objects are made of matter.

Suppose your class takes a field trip to a museum. During the course of the day you see mammoth bones, sparkling crystals, hot-air balloons, and an astronaut's space suit. All of these things are matter.

Matter is what makes up all of the objects and living organisms in the universe. As you will see, **matter** is anything that has mass and takes up space. Your body is matter. The air that you breathe and the water that you drink are also matter. Matter makes up the materials around you. Matter is made of particles called atoms, which are too small to see. You will learn more about atoms in the next section.

Not everything is matter. Light and sound, for example, are not matter. Light does not take up space or have mass in the same way that a table does. Although air is made of atoms, a sound traveling through air is not.

CHECK YOUR READING What is matter? How can you tell if something is matter?

MAIN IDEA AND DETAILS
As you read, write the blue headings on the left side of a two-column chart. Add details in the other column.

Mass is a measure of the amount of matter.

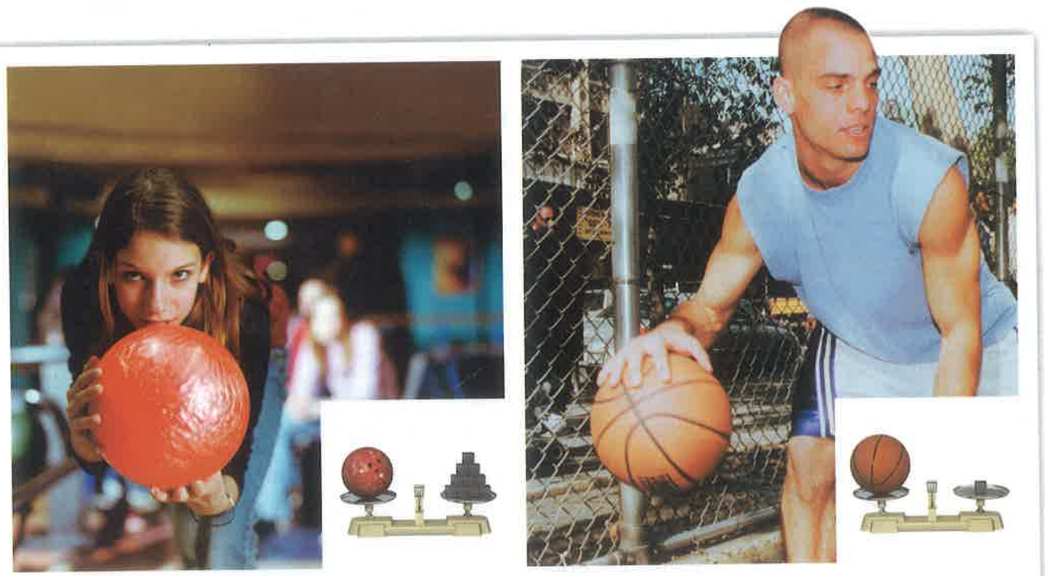
Different objects contain different amounts of matter. **Mass** is a measure of how much matter an object contains. A metal teaspoon, for example, contains more matter than a plastic teaspoon. Therefore, a metal teaspoon has a greater mass than a plastic teaspoon. An elephant has more mass than a mouse.

CHECK YOUR READING How are matter and mass related?

Measuring Mass

When you measure mass, you compare the mass of the object with a standard amount, or unit, of mass. The standard unit of mass is the kilogram (kg). A large grapefruit has a mass of about one-half kilogram. Smaller masses are often measured in grams (g). There are 1000 grams in a kilogram. A penny has a mass of between two and three grams.

How can you compare the masses of two objects? One way is to use a pan balance, as shown below. If two objects balance each other on a pan balance, then they contain the same amount of matter. If a basketball balances a metal block, for example, then the basketball and the block have the same mass. Beam balances work in a similar way, but instead of comparing the masses of two objects, you compare the mass of an object with a standard mass on the beam.



A bowling ball and a basketball are about the same size, but a bowling ball has more mass.

Measuring Weight

When you hold an object such as a backpack full of books, you feel it pulling down on your hands. This is because Earth's gravity pulls the backpack toward the ground. Gravity is the force that pulls two masses toward each other. In this example, the two masses are Earth and the backpack. **Weight** is the downward pull on an object due to gravity. If the pull of the backpack is strong, you would say that the backpack weighs a lot.

Weight is measured by using a scale, such as a spring scale like the one shown on the right, that tells how hard an object is pushing or pulling on it. The standard scientific unit for weight is the newton (N). A common unit for weight is the pound (lb).

Gravity is pulling down on both the girl and the backpack. The heavier the backpack is, the stronger the pull of gravity is on it.

Mass and weight are closely related, but they are not the same. Mass describes the amount of matter an object has, and weight describes how strongly gravity is pulling on that matter. On Earth, a one-kilogram object has a weight of 9.8 newtons (2.2 lb). When a person says that one kilogram is equal to 2.2 pounds, he or she is really saying that one kilogram has a weight of 2.2 pounds on Earth. On the Moon, however, gravity is one-sixth as strong as it is on Earth. On the Moon, the one-kilogram object would have a weight of 1.6 newtons (0.36 lb). The amount of matter in the object, or its mass, is the same on Earth as it is on the Moon, but the pull of gravity is different.

SIMULATION CLASSZONE.COM
Compare weights on different planets.

CHECK YOUR READING What is the difference between mass and weight?

Volume is a measure of the space matter occupies.

Matter takes up space. A bricklayer stacks bricks on top of each other to build a wall. No two bricks can occupy the same place because the matter in each brick takes up space.

The amount of space that matter in an object occupies is called the object's **volume.** The bowling ball and the basketball shown on page 10 take up approximately the same amount of space. Therefore, the two balls have about the same volume. Although the basketball is hollow, it is not empty. Air fills up the space inside the basketball. Air and other gases take up space and have volume.

RESOURCE CENTER
CLASSZONE.COM
Find out more about volume.

Determining Volume by Formula

There are different ways to find the volume of an object. For objects that have well-defined shapes, such as a brick or a ball, you can take a few measurements of the object and calculate the volume by substituting these values into a formula.

A rectangular box, for example, has a length, a width, and a height that can be measured. To find the volume of the box, multiply the three values.

Volume = length • width • height
$V = lwh$

If you measure the length, the width, and the height of the box in centimeters (cm), the volume has a unit of centimeters times centimeters times centimeters, or centimeters cubed (cm^3). If the measurements are meters, the unit of volume is meters cubed (m^3). All measurements must be in the same unit to calculate volume.

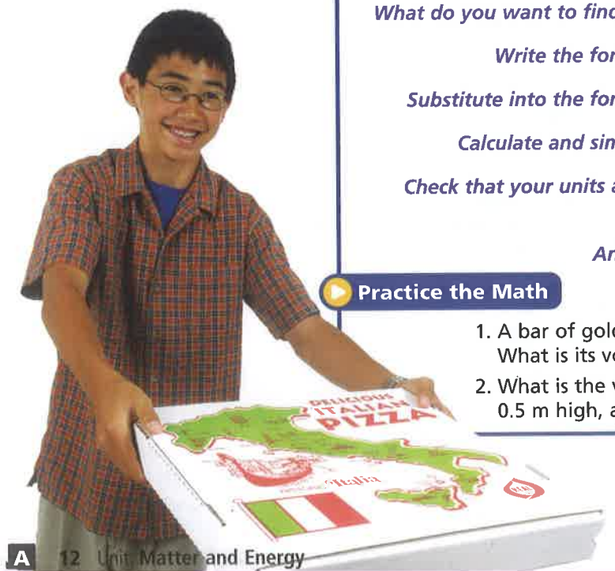
Other regular solids, such as spheres and cylinders, also have formulas for calculating volumes. All formulas for volume require multiplying three dimensions. Units for volume are often expressed in terms of a length unit cubed, that is, a length to the third power.

Calculating Volume

Sample Problem

What is the volume of a pizza box that is 8 cm high, 38 cm wide, and 38 cm long?

What do you know?	length = 38 cm, width = 38 cm, height = 8 cm
What do you want to find out?	Volume
Write the formula:	$V = lwh$
Substitute into the formula:	$V = 38\ cm \cdot 38\ cm \cdot 8\ cm$
Calculate and simplify:	$11{,}552\ cm \cdot cm \cdot cm = 11{,}552\ cm^3$
Check that your units agree:	Unit is cm^3. Unit of volume is cm^3. Units agree.
Answer:	$11{,}552\ cm^3$



Practice the Math

1. A bar of gold is 10 cm long, 5 cm wide, and 7 cm high. What is its volume?
2. What is the volume of a large block of wood that is 1 m long, 0.5 m high, and 50 cm wide?

Measuring Volume by Displacement

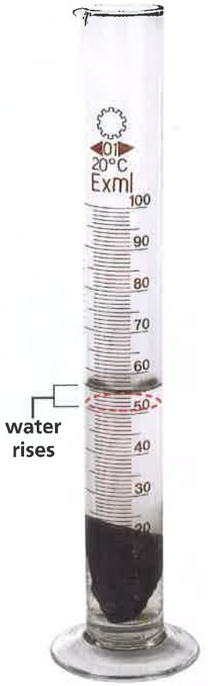
Although a box has a regular shape, a rock does not. There is no simple formula for calculating the volume of something with an irregular shape. Instead, you can make use of the fact that two objects cannot be in the same place at the same time. This method of measuring is called displacement.

1. Add water to a graduated cylinder. Note the volume of the water by reading the water level on the cylinder.
2. Submerge the irregular object in the water. Because the object and the water cannot share the same space, the water is displaced, or moved upward. Note the new volume of the water with the object in it.
3. Subtract the volume of the water before you added the object from the volume of the water and the object together. The result is the volume of the object. The object displaces a volume of water equal to the volume of the object.

You measure the volume of a liquid by measuring how much space it takes up in a container. The volume of a liquid usually is measured in liters (L) or milliliters (mL). One liter is equal to 1000 milliliters. Milliliters and cubic centimeters are equivalent. This can be written as 1 mL = 1 cm^3. If you had a box with a volume of one cubic centimeter and you filled it with water, you would have one milliliter of water.

In the first photograph, the graduated cylinder contains 50 mL of water. Placing a rock in the cylinder causes the water level to rise from 50 mL to 55 mL. The difference is 5 mL; therefore, the volume of the rock is 5 cm^3.

Measure the volume of water without the rock.



Measure the volume of water with the rock in it.

1.1 Review

KEY CONCEPTS

1. Give three examples of matter.
2. What do weight and mass measure?
3. How can you measure the volume of an object that has an irregular shape?

CRITICAL THINKING

4. **Calculate** What is the volume of a box that is 12 cm long, 6 cm wide, and 4 cm high?
5. **Synthesize** What is the relationship between the units of measurement for the volume of a liquid and of a solid object?

CHALLENGE

6. **Infer** Why might a small increase in the dimensions of an object cause a large change in its volume?